of nature? John Locke had furnished them with the solution—true *civitas Dei*—in which every man's faculty was such as to allow him to control all those desires which ran counter to the good of mankind, and cherish those only which would benefit the welfare of the whole of society, and which every man felt as sufficiently true to enable him to know what he ought to do. Society as now constituted consisted of a considerable number of the foolish and the ignorant—a small proportion of good genuine knaves and a sprinkling of capable and honest men, by whose efforts the former were kept in a reasonable restraint. Such being the case, he could not see how the limit could be laid down as to the question which, under some circumstances, the action of Government might be rightfully carried on, The question was where they ought to draw the line between those things which a State ought to do, and which they ought not to do. The difficulty which met the statesmen was the same as that which met all of them in individual life. Moore and Owen, and all the great modern Socialists, bear witness that Government might attain its end for the good of the people by some more effectual process than the very simple and easy one of letting all matters of enterprise alone. He thought that the science of politics was but imperfectly known; and that perhaps they would be able to get clearer notions of what a State might or might not do, if they estimated the truth of the proposition, that the end of government is the good of mankind. It was necessary to consider a little what the good of mankind really was. The good of mankind meant the admission of every man to all the happiness which he could enjoy without diminishing the happiness of his fellow men. Having dwelt at some length on this point, Mr. Huxley went on to say that it was universally agreed that it would be useless to admit the freedom of sympathy between man and man directly; but he could see no reason why the State might not do many things towards that end indirectly. He was not going to argue that there should be a State science, or a State organisation, such as they had seen in France, by which all scientific teaching was to be properly regulated. On the contrary, the State had left local enterprise to work out its own ends as soon as local intelligence and energy proved itself equal to the task. These local efforts not only benefited the localities; but every means of teaching, every stimulus given to intellectual life was so much positively added to the wealth and welfare of the nation, and as such deserved some equivalent modicum of support from the general purse. But if the positive advancement of the peace, wealth, and intellectual and moral development of its members were the objects which the representative of the corporate authority of society, the Government, might justly strive after in the fulfilment of its end, which was the good of mankind, then it was clear that the Government might undertake the education of the people, for education promoted peace by teaching men the realities of life, and the obligations which were involved in the very existence of society; and promoted the intellectual development, not only by training the individual intellect, but by sifting out from the mass of ordinary or inferior capacities those which were competent to increase the general welfare by occupying higher positions; and lastly, it promoted morality and refinement by teaching men to discipline themselves, and leading them to see that the highest, as it was the only permanent, content was to be attained not by groveling in the rank stream of the foulest sense, but by continually striving towards those higher peaks where, resting in eternal calm, reason discerned the undefined but bright ideal of the highest good, "a cloud by day, a pillar of fire by night."

ON THE STRUCTURE OF THE PALÆOZOIC CRINOIDS[*]

THE best known living representatives of the Echinoderm class Crinoidea are the genera *Antedon* and *Pentacrinus*—the former the feather stars, tolerably common in all seas; the latter the stalked sea-lilies, whose only ascertained habitat, until lately, was the deeper portion of the sea of the Antilles, whence they were rarely recovered by being accidentally entangled on fishing-lines. Within the last few years Mr. Robert Damon, the well-known dealer in natural history objects in Weymouth, has procured a considerable number of specimens of the two West Indian *Pentacrini*, and Dr. Carpenter and the author had an opportunity of making very detailed observations both on the hard and the soft parts. These observations will shortly be published.

The genera *Antedon* and *Pentacrinus* resemble one another in all essential particulars of internal structure. The great distinction between them is, that while *Antedon* swims freely in the water, and anchors itself at will by means of a set of "dorsal cirri," *Pentacrinus* is attached to a jointed stem, which is either permanently fixed to some foreign body, or, as in the case of a fine species procured off the coast of Portugal during the cruise of the *Porcupine* in the summer of 1870, loosely rooted by a whorl of terminal cirri in soft mud. Setting aside the stalk, in *Antedon* and *Pentacrinus* the body consists of a rounded central disc and ten or more pinnated arms. A ciliated groove runs along the "oral" or "ventral" surface of the pinnules and arms, and these tributary brachial grooves gradually coalescing, terminate in five radial grooves, which end in an oral opening, usually subcentral, sometimes very excentric. The œsophagus, stomach, and intestine coil round a central axis, formed of dense connective tissue, apparently continuous with the stroma of the ovary, and of involutions of the perivisceral membrane; and the intestine ends in an anal tube, which opens excentrically in one of the inter-radial spaces, and usually projects considerably above the surface of the disc. The contents of the stomach are found uniformly to consist of a pulp composed of particles of organic matter, the shields of diatoms, and the shells of minute foraminifera. The mode of nutrition may be readily observed in *Antedon*, which will live for months in a tank. The animal rests attached by its dorsal cirri, with its arms expanded like the petals of a full-blown flower. A current of sea water, bearing organic particles, is carried by the cilia along the brachial grooves into the mouth, the water is exhausted of its assimilable matter in the alimentary canal, and is finally ejected at the anal orifice. The length and direction of the anal tube prevent the exhausted water and the fœcal matter from returning at once into the ciliated passages.

In the probably extinct family Cyathocrinidæ, and notably in the genus *Cyathocrinus*, which the author took as the type of the Palæozoic group, the so-called Crinoidea Tessellata, the arrangement, up to a certain point, is much the same. There is a widely-expanded crown of branching arms, deeply grooved, which doubtless performed the same functions as the grooved arms of *Pentacrinus*; but the grooves stop short at the edge of the disc, and there is no central opening, the only visible apertures being a tube, sometimes of extreme length, rising from the surface of the disc in one of the inter-radial spaces, which is usually greatly enlarged for its accommodation by the intercalation of additional perisomatic plates, and a small tunnel-like opening through the perisom of the edge of the disc opposite the base of each of the arms, in continuation of the groove of the arm. The functions of these openings, and the mode of nutrition of the crinoid having this structure, have been the subject of much controversy.

The author had lately had an opportunity of examining some very remarkable specimens of *Cyathocrinus arthriticus*, procured by Mr. Charles Ketley from the upper Silurians of Wenlock, and a number of wonderfully perfect examples of species of the genera *Actinocrinus*, *Platycrinus*, and others, for which he was indebted to the liberality of Mr. Charles Wachsmuth, of Burlington, Ohio, and Mr. Sidney Lyon, of Jeffersonville, Indiana; and he had also had the advantage of studying photographs of plates, showing the internal structure of fossil crinoids, about to be published by Messrs. Meek and Worthen, State Geologists for Illinois. A careful examination of all these, taken in connection with the description by Prof. Lovén, of *Hyponome Sarsii*, a recent crinoid lately procured from Torres Strait, had led him to the following general conclusions.

In accordance with the views of Dr. Schultze, Dr. Lütken, and Messrs. Meek and Worthen, he regarded the proboscis of the tesselated crinoids as the anal tube, corresponding in every respect with the anal tube in *Antedon* and *Pentacrinus*, and he maintained the opinion which he formerly published (Edin. New Phil. Jour. Jan. 1861), that the valvular "pyramid" of the Cystideans is also the anus. The true mouth in the tesselated crinoids is an internal opening vaulted over by the plates of the perisom, and situated in the axis of the radial system more or less in advance of the anal tube, in the position assigned by Mr. Billings to his "ambulacral opening." Five, ten, or more openings round the edge of the disc lead into channels continuous with the grooves on the ventral surface of the arms, either covered over like the mouth by perisomatic plates, the inner surface of which they more or less impress, and supported beneath by chains

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[*] Abstract of a paper read before the Royal Society of Edinburgh, by Prof. Wyville Thomson, April 3, 1871.

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of ossicles; or, in rare cases (*Amphoracrinus*), tunnelled in the substance of the greatly thickened walls of the vault. These internal passages, usually reduced in number to five by uniting with one another, pass into the internal mouth, into which they doubtless lead the current from the ciliated brachial grooves.

In connection with different species of *Platyceras* with various crinoids, over whose anal openings they fix themselves, moulding the edges of their shells to the form of shell of the crinoid, is a case of "commensalism," in which the mollusc takes advantage for nutrition and respiration of the current passing through the alimentary canal of the echinoderm. *Hyponome Sarsii* appears, from Prof. Lovén's description, to be a true crinoid, closely allied to *Antedon*, and does not seem in any way to resemble the Cystideans. It has, however, precisely the same arrangement as to its internal radial vessels and mouth which we find in the older crinoids. It bears the same structural relation to *Antedon* which *Extracrinus* bears to *Pentacrinus*.

Some examples of different tesselated crinoids from the Burlington limestone, most of them procured by Mr. Wachsmuth, and described by Messrs. Meek and Worthen, show a very remarkable convoluted plate, somewhat in form like the shell of a *Scaphander*, placed vertically in the centre of the cup, in the position occupied by the fibrous axis or columella in *Pentacrinus* and *Antedon*. Mr. Billings, the distinguished palæontologist to the Survey of Canada, in a very valuable paper on the structure of the Crinoidea, Cystidea, and Blastoidea (*Silliman's Journal*, January 1870), advocates the view that the plate is connected with the apparatus of respiration, and that it is homologous with the pectinated rhombs of Cystideans, the tube apparatus of Pentremites, and the sand-canal of Asterids. Messrs. Meek and Worthen and Dr. Lütken, on the other hand, regard it as associated in some way with the alimentary canal and the function of nutrition.

The author strongly supported the latter opinion. The perivisceral membrane in *Antedon* and *Pentacrinus* already alluded to, which lines the whole calyx, and whose involutions, supporting the coils of the alimentary canal, contribute to the formation of the central columella, is crowded with miliary grains and small plates of carbonate of line; and a very slight modification would convert the whole into a delicate fenestrated calcareous plate. Some of the specimens in Mr. Wachsmuth's collection show the open reticulated tissue of the central coil continuous over the whole of the interior of the calyx, and rising on the walls of the vault, thus following almost exactly the course of the perivisceral membrane in the recent forms. In all likelihood, therefore, the internal calcareous network in the crinoids, whether rising into a convoluted plate or lining the cavity of the crinoid head, is simply a calcified condition of the perivisceral sac.

The author was inclined to agree with Mr. Rofe and Mr. Billings in attributing the functions of respiration to the pectinated rhombs of the Cystideans and the tube apparatus of the Blastoids. He did not see, however, that any equivalent arrangement was either necessary or probable in the crinoids with expanded arms, in which the provisions for respiration, in the form of tubular tentacles and respiratory films and lobes over the whole extent of the arms and pinnules, are so elaborate and complete.

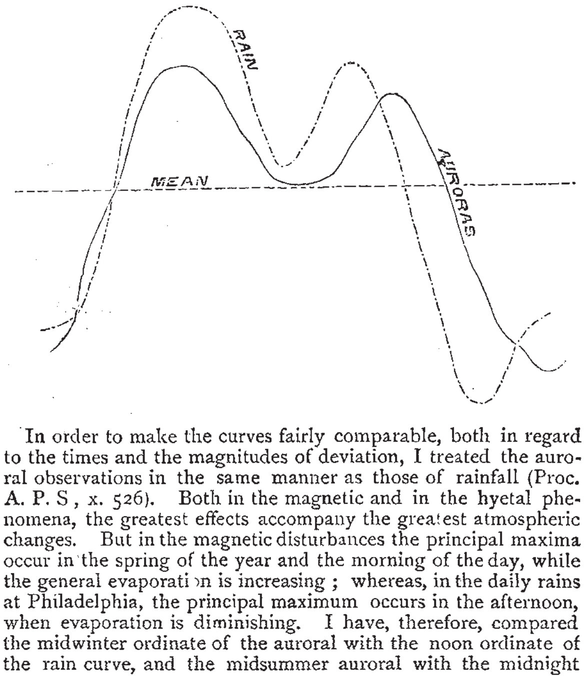
ON THE RELATION OF AURORAS TO GRAVITATING CURRENTS*

PROF. LOOMIS'S observations of the number of Auroras in each month of 1869 and 1870 (*American Journal of Science*, 3rd S., i. 309) are specially noteworthy, both because of the careful accuracy of the observer, and because they are the first published observations which furnish satisfactory data for an approximate determination of the laws of auroral distribution.

If the auroras are, as is now generally believed, luminous manifestations of terrestrial magnetism, it seems reasonable to look to them for some additional evidence upon the question of the relation between magnetic and gravitating currents. Messrs. Baxendell and Bloxam have already pointed out some resemblances between hyetal and magnetic curves (see Proc. A. P. S., x. 368) and if analogous resemblances can be traced between hyetal and auroral curves, they will be interesting and suggestive.

I have not found the similarity between the annual distribution of rainfalls and auroras sufficiently striking to impress any one who has not made a special study of the causes of resemblance and difference. But, as I have repeatedly urged, currents are subject to an increased number of disguising disturbances, in proportion to the sluggishness of their motion, and the time which is consequently required for their formation and change. We may very reasonably look for analogies between the daily and the annual auroral or magnetic curves, of a character for which we could hope to find no parallel in wind, rain, or ocean current curves.

If we desire, therefore, to find evidence of the joint influence of solar expansion and gravitating equilibrium, we should look where it is most likely to be found, and to the best of the observations which may be supposed to be fairly comparable. There are similar variations of solar attitude, and consequently increasing and diminishing solar force, in the day and in the year, but the effects of these variations upon the precipitation of vapour are more likely to be shown in their greatest simplicity by the means of observations at different hours of the day than at different seasons of the year. I know of no published observations of this character at New Haven, but there are some extending over a long series of years at Philadelphia and at Greenwich, the curves at each station indicating minima of rainfall at noon and midnight, and maxima in the morning and evening. The difference of longitude between Philadelphia and New Haven being less than 2½°, it is not likely that there is any material difference in the daily rain-curves at the two places.



In order to make the curves fairly comparable, both in regard to the times and the magnitudes of deviation, I treated the auroral observations in the same manner as those of rainfall (Proc. A. P. S, x. 526). Both in the magnetic and in the hyetal phenomena, the greatest effects accompany the greatest atmospheric changes. But in the magnetic disturbances the principal maxima occur in the spring of the year and the morning of the day, while the general evaporation is increasing; whereas, in the daily rains at Philadelphia, the principal maximum occurs in the afternoon, when evaporation is diminishing. I have, therefore, compared the midwinter ordinate of the auroral with the noon ordinate of the rain curve, and the midsummer auroral with the midnight hyetal ordinate.

The auroral observations and the normal ordinates of the accompanying curves are given in the following table. I presume no one will doubt that the condensation of vapour, which is represented by the rain-curve, is occasioned by the simple operation of gravitation in blending currents of different temperatures, and I see no reason for postulating any different law for the development of electricity and magnetism in the aurora.

Comparative Table of Auroras and Rainfalls

Month.	No. of Aurorals.	Normals.	Hours.	Normals of Rain.
		88	0	91
January	32	90	1	91
		94	2	93
February	31	98	3	98
		103	4	105
March	41	107	5	110
		109	6	113
April	44	109	7	113
		108	8	112

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* Read before the American Philosophical Society, May 5, 1871, by Pliny Earle Chase.

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